

# DESIGN CHALLENGE 1<sup>st</sup> & 2<sup>nd</sup> YEAR GENERAL SPECIFICATION 2021

IMechE DESIGN CHALLENGE

GUIDANCE FOR ALL PROJECTS



# **General Specification for the 2021 1<sup>st</sup> and 2<sup>nd</sup> Year Undergraduate Design Challenge**

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Note: this specification must be read in conjunction with the respective document "IMechE 1<sup>st</sup> (or 2<sup>nd</sup>) Year Design Challenge - Project Specification 2021" available on the IMechE Design Challenge website.

**Please check the supplementary document**

**"IMechE 1<sup>st</sup> & 2<sup>nd</sup> Year Design Challenge - COVID-19  
Amendments 2021"**

**for any special arrangements for this year's competition,  
available on the**

**IMechE Design Challenge website.**

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## List of Amendments:

Version	Page	Details	Date
1.0	-	Full Release (no changes from DRAFT V0.2)	28-10-2020

# 1. Introduction and Purpose of the Design Challenge

This specification and rules of engagement are to be used in conjunction with the Project Specification adopted at the time.

The purpose of the Design Challenge Competition is to simulate the requirements of a professional engineer so that students are exposed to the real world of engineering where they have to think for themselves and apply a systematic approach to solve an engineering requirement.

- 1.1 The competition is open to teams of two to five engineering degree students at the appropriate level.
- 1.2 Each team can use just one device at the competition, but all students who work on the challenge will benefit from the learning experience of applying their engineering knowledge.
- 1.3 Working in teams, students have to design, build and test a self-contained device from a precise Project Specification. From this specification they have to produce a design solution, make it, test it and compete, to win a place in the IMechE Regional Competition.
- 1.4 There are five competition elements to the Design Challenge at the Regional Competition and National Final:

## Main Competition

Design, build and test a device to compete with other teams.

## Design Competition

Create a virtual prototype of your device.

## Poster Competition

Produce a poster to publicise the teams' work. The poster is a demonstration of the team's ability to sell their design solution pictorially.

## Presentation Competition

Give a short presentation explaining the design and development of their device to demonstrate their verbal & presentational skills.

## Peer Review (Regional Competition Only)

Submit a peer review where all students have the chance to vote for the best engineered solution to the requirement.

## Design Excellence (National Competition Only)

Present their designs to the judges to determine the best Engineering design using sound principles with an acceptable appearance.

The above covers the general requirements of a professional engineer.

1.5 The format of the Regional Competition and National Final is as follows:

<u>Regional Competition</u>	<u>National Final</u>
Main Competition	Main Competition
Design Competition	Design Competition
Poster	Poster
Presentation	Presentation
Peer Review	Design Excellence

1.6 All teams must compete in all sections of the competition.

1.7 Points will be given for all sections of the competition.

1.8 Points will be awarded for the heats and final of the Main Competition.

1.9 For the Regional Competition there will be winners for each of the competition elements.

1.10 In the Regional Competition each section of the Main Competition, Design Competition, Poster, Presentation and Peer Review will be treated separately. Performance in one element will not affect any other section.

1.11 The winner of the Main Competition in each region will progress to the National Final.

1.12 For the National Final, all the points scored for each section of the competition will be totalled to determine an outright champion.

Poster	10
Presentation	10
Design Competition	10
Design Excellence	10
Main Competition	60
Total	100

1.13 In the National Final, in the event of a tie of overall points after the competition final, the team with the highest points in the Main Competition will be the champions.

1.14 All teams must compete in the Main Competition, Design Competition and the Peer Review, or Design Excellence at the National Final.

1.15 In regions where there is a large number of teams, it is permissible for each university to enter one team in the Poster Competition and one team in the Presentation Competition. This should only be considered due to time restraints.

1.16 Under these circumstances, if a university enters only one team, they must compete in both the Poster and the Presentation Competitions.

1.17 In the spirit of the competition, all teams within each university should make a presentation and produce a poster, even if they do not get a place in the Regional

Competition. If they do reach the final, they may not necessarily have to present both, due to time restraints.

The amount of time allocated to the challenge at each university may be different. This should not affect the fairness of the competition.

Most universities have embedded the Design Challenge into their learning programme, either initially, or after a pilot year, and it is said to be beneficial to both the university and the students.

The competitions are normally held in March or April, but this is not prescriptive because it can be at any time to suit the universities in the region during the academic year.

The National Final of the Design Challenge Competition is held in October of each year at IMechE HQ.

## 2. Prizes and Certificates

In the Regional Competition, the winning University of the Competition will receive the Regional Design Challenge Trophy to keep for one year, or until the next Regional Competition, and a certificate. All members of the winning team will receive a certificate.

In the National Final, the winning Region (University) will receive the prestigious Design Challenge Trophy to keep for one year, or until the next National competition, and a certificate. All members of the winning team will receive a replica trophy to keep, together with a certificate.

Certificates will be available for the following in both regional and national finals:

The runner up team.

The third placed team.

The winning team of the Design Competition.

The winning team of the Presentation Competition.

The winning team of the Poster Competition.

The winning team of the Peer Review (Regional Competition).

The winning team of the Design Excellence Competition (National Final).

All members of the other participating teams will receive certificates.

Certificates will only be awarded to participating team members and not to team supervisors or university staff members.

### 3. Sponsor Awards

In addition to the IMechE prizes, the Sponsor Awards will be given by the competition sponsors. These awards can be for specific aspects of the challenge, for teams and individuals. They may also include opportunities for industrial visits or placements with the sponsor. Please check for full details on the IMechE Design Challenge website and for up-to-date information.

Please note that the Sponsor Awards are not a formal, or obligatory, part of the competition. The requirements for these awards have no bearing on the competition itself.

### 4. The Four Adopted Design Challenge Projects

Four suitable projects have been determined for the Design Challenge and they will be introduced consecutively in each region over a four-year period.

Each year, one of the selected projects is adopted and applied in each region and the same specification and rules of engagement are used so that the Regional Competitions are identical to each other. Subsequently the winning team in the National Final is the true champion of the challenge.

Each of the four projects has a detailed Project Specification for the device requirements, but in each case this General Specification will apply for the competition and the rules of engagement.

Each of the four adopted challenge projects represents a real-life application so that the students can see a reason for developing such a project.

The four Design Challenge projects are as follows and they are run in the order shown over the 4-year period:

- 1 Repeatable Vehicle.
- 2 Internal Pipe Climber.
- 3 Line Launcher.
- 4 External Pipe Climber.

## 5. Competition Rules for All Projects.

### GENERAL

- 5.1 Devices should be manufactured using available facilities and materials, using processes that students can themselves work with under minimal guidance.
- 5.2 Off-the-shelf components may also be purchased, such as motors, batteries, gears, bearings, fasteners and so on.
- 5.3 All components, whether manufactured or bought, must comply with the Design Challenge regulations.
- 5.4 All devices must be 'signed off' by the academic staff member of the individual university, to say that their teams' device meets all of the scrutineering rules, before the Main Competition.
- 5.5 On the day of the competition, and after successfully completing the scrutineering process, teams will be given a sticker. This must be attached to the device as proof of scrutineering.
- 5.6 Any team which tries to enter a heat without this sticker will not be allowed to compete.

### COST

- 5.7 The total cost of the device (including VAT at 20%) is to be as follows:
  - under £30 for the 1st year competition.
  - under £100 for the 2nd year competition.
- 5.8 The total cost must include all parts and materials priced at, or over, £0.20 used to make the device. Parts with a value of less than £0.20 do not need to be included in the total cost.
- 5.9 A full parts list with all itemised costs, including those under £0.20, must be produced according to the Design Competition rules in the Project Specification (see Bill of Materials).
- 5.10 All purchased materials and parts must be listed with the as-new normal retail purchase price from established suppliers (including VAT, but excluding carriage).
- 5.11 Invoices, receipts, or proof-of-purchase must be provided ahead of the competition for all materials and bought components for inspection by the judges during the static competition and scrutineering.
- 5.12 Components or materials 'in-kind', or provided free by the university, or from any other source, must be included in the parts list, and costed as appropriate at its as-new price.



- 5.13 A component or material is considered to be 'in-kind' if it is not commercially available for purchase by other teams or cannot be supplied at the same price.
- 5.14 In addition, the total cost must also include any replacement, or substitute parts, used during the heats and final of the Main Competition. This must include spare sets of batteries, for example, changed during the heats, and they must be counted towards the total cost of the device. This rule is to prevent teams using expensive batteries and replacing them as new for each heat, without including them in the cost.
- 5.15 Teams may be expected to justify the purchase price of any item of the device.
- 5.16 The cost of manufactured parts must be calculated based on the raw materials used.
- 5.17 Standard sheet/bar materials should be charged as a proportion used per device, within reason. For example, if the purchase of a 6m length of steel bar cost £18 and 200mm were used, the cost recorded would be £0.60 ( $£18 \times 0.2 / 6.0$ ). Purchase of 600m of bar would be deemed unreasonable.
- 5.18 The cost of generic tools (drills, saws, files, etc.) need not be included. Likewise, the cost of a battery charger, or air compressor, etc., can be excluded, as they are considered general-use workshop items.

#### ADDITIVE MANUFACTURING

- 5.19 Rapid prototyping or additive manufacture is permitted. Teams should use this method for making individual parts and not for producing the whole assembly.
- 5.20 Parts produced this way will be costed the same as other raw materials. For instance, a 2.3kg reel of filament costing £57.00 will be costed at 2.48p per gram.

#### SAFETY

- 5.21 Teams are encouraged to think very carefully about safety. All devices must be 'signed off' by the academic staff members of the individual universities to say that their students' devices are deemed safe to operate in a lecture theatre or sports hall environment at the regional competition.
- 5.22 Teams must supply their own safety glasses as appropriate. Teams that fail to provide suitable safety equipment will have their top heat score erased.
- 5.23 Lithium batteries are not permitted due to the risk of fire and explosion, but other types of safe, rechargeable batteries may be used.
- 5.24 Pressurised air/gas systems are allowed but they must be declared safe and reasonable by the participating University and not subject to the "Pressure Equipment Directive" (directive 97/23/EC) namely volume <1 L, pressure volume <50 bar L.
- 5.25 No explosive charges or combustion can be used.

5.26 Propulsion systems may not include explosives or combustion. Devices must be regarded as safe and reasonable and conform with the General Specification as judged by the member of staff responsible for the team. Consideration should be given to guarding if there is risk of entanglement or entrapment.

## 6. Scoring for the Design Competition.

6.1 The virtual prototype and bill of materials will be assessed and judged by the appointed judges, in accordance with the marking scheme below:

<b>Judging Criteria</b>		<b>Weight (%)</b>
<b>Virtual Prototype</b>	Accuracy of the virtual model down to the finer details, or similarity compared to the real parts on display	20
	Accuracy of the masses and inertias of the virtual model	10
	Compliance with Design Challenge rules	10
<b>Bill of Materials</b>	Overall accuracy of the BoM – including all items in the assembly	20
	Cost analysis for the entire device, including items less than 20p	20
	Accuracy of costs for manufactured parts	10
	Accuracy of costs for bought components, including spares	10
<b>Total</b>		<b>100</b>
<b>Score = Total / 10</b>		<b>10</b>
<b>Rounded up to whole number</b>		

## 7. Rules and Scoring for the Poster Competition

- 7.1 The poster should be A1 size in portrait format. It should clearly display the logos of the team's university and of the IMechE.
- 7.2 The poster should concisely describe the device, how it operates and the engineering principles it is based on. It should include, but is not limited to:
- sketch, 3D visualisation or 2D technical drawings representing the device,
  - text to explain important features shown in the drawings,
  - details of how and why the device works, using diagrams if necessary, and
  - brief details of the team members.
- 7.3 Detailed costing of the device is not required on the poster, but a summary should be included.
- 7.4 The poster is a demonstration of the team's ability to sell their design solution.
- 7.5 The poster will be assessed by the appointed judges, in accordance with the marking scheme below:

<b>Judging Criteria</b>		<b>Weight (%)</b>
<b>Visual Impact</b>	Compliance with rules – size (A1) and orientation (portrait)	15
	Obvious information on the university represented (logos) and the team members' names	15
	Good use of colour, layout, text and space to convey meaning	15
<b>Technical Content</b>	Clear but brief textual description of the competing device	15
	Clear diagram(s) – sketch, rendering or CAD model – of the device	15
	Evidence of the engineering science underpinning the device	15
	Summary costing of major components of the device	10
<b>Total</b>		<b>100</b>
<b>Score = Total / 10</b>		<b>10</b>
<b>Rounded up to whole number</b>		<b>10</b>

## 8. Rules and Scoring for the Presentation Competition

- 8.1 Presentations should be submitted (on a memory stick) on arrival at the Regional Competition or National Final.
- 8.2 The maximum length of the presentation is five minutes plus, typically, two minutes for questions for the Regional Competitions. For the National Final the timings are seven minutes and three minutes respectively. The presentation can be delivered by any number of team members, from one person, to all members of the team. Computer and projector facilities with common software will be available.
- 8.3 The presentation should include, but is not limited to;
- the principal features of the final design,
  - the engineering science that underpins the device,
  - the steps the team followed to arrive at the design, and
  - the total cost of the final design and if/how costs influenced the final design
- 8.4 The team will be required to answer questions on their design.
- 8.5 The presentation is a demonstration of the team's ability to verbally present their design solution.
- 8.6 The presentation will be assessed by the appointed judges, in accordance with the marking scheme below:

<b>Judging Criteria</b>		<b>Weight (%)</b>
<b>Presentation Style</b>	Audience Engagement	15
	Quality of spoken presentation (well structured, fluent, clear etc.)	15
	Quality of visual aids (clear and easily readable, do not duplicate spoken presentation etc.)	15
<b>Technical Content</b>	Principal features of the final design	15
	Steps followed to reach the final design, including costing of the device	15
	Engineering science that underpins the final design	15
	Answer to judges' questions	10
<b>Total</b>		<b>100</b>
<b>Score = Total / 10</b>		<b>10</b>
<b>Rounded up to whole number</b>		<b>10</b>

## 9. Rules for the Peer Review Competition

- 9.1 Each team should examine the device from each of the other teams without handling them.
- 9.2 Whilst the peer review is being carried out there must be at least one member of each team present to answer questions etc.
- 9.3 During the examination teams should be looking for the following;
  - a. design principles used,
  - b. the simplicity of the design,
  - c. the robustness of the design,
  - d. the manufacturing excellence, and
  - e. the general appearance.
- 9.4 Teams then vote for their top three using the voting slips provided on the day.
- 9.5 The competition judges should cast a cursory eye over the procedure during the peer review.
- 9.6 The peer review competition only takes place at the Regional Competitions.

## 10. Rules and Scoring for the Design Excellence Competition

- 10.1 Each team should display their device on the table beneath their poster.
- 10.2 The device will be judged under the same criteria as detailed in Section 3.4.
- 10.3 The design excellence competition only takes place at the National Final.
- 10.4 The design excellence will be assessed by the appointed judges, in accordance with the marking scheme below:

<b>Judging Criteria</b>	<b>Weight (%)</b>
Design principles applied	20
Simplicity of design	20
Robustness	20
Manufacturing excellence	20
Appearance	20
<b>Total</b>	<b>100</b>
<b>Score = Total / 10</b> <b>Rounded up to whole number</b>	<b>10</b>

## 11. Enforcement of the Rules

- 11.1 On matters relating to test equipment and procedure, the authority will be the Chair of the IMechE Design Challenge organising committee, or his/her delegated representative(s).
- 11.2 The panel of judges for the competition consists of impartial IMechE and university representatives.
- 11.3 The decisions of the panel of judges will be final.
- 11.4 In addition to the rules for the Regional Competition and National Final outlined above, universities are responsible for internally ensuring that the spirit of the competition is adhered to during the design and make stages.
- 11.5 Appeals: If a team wishes to lodge a complaint, to query a procedure or rule infringement, they must do so through the Chair of the IMechE Design Challenge organising committee, or his/her delegated representative(s). Any complaint will be investigated immediately, by at least two judges, and a response will be issued within a reasonable time. This decision will be final and not subject to further appeal.
- 11.6 Appeals must be raised by a nominated team leader. The remaining team members, team supervisors, or university staff members, can only contribute to an appeal if requested to do so by the Chair of the IMechE Design Challenge organising committee, or his/her delegated representative(s).

Note - Judges are allowed to vary the rules slightly, if it is deemed necessary, to maintain the smooth running of the competition.